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Demonstration of Broadband Absorption Spectroscopy of CN(X2Σ+→B2Σ+) in the Low Density Electric Arc Shock Tube

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Abstract

The Electric Arc Shock Tube (EAST) is an impulse facility used to study gas kinetics and radiation in hypersonic shock waves, and the new 21.4” Low Density Shock Tube (LDST) driven section was inaugurated in September 2024. EAST’s main diagnostics rely on four Optical Emission Spectrometers (OES) to capture radiative emission over a broad wavelength range and a spatial domain of about 10 cm after the shock front. However, measurements are limited to transitions from excited states. This work discusses the demonstration of broadband absorption spectroscopy of CN(X2Σ+ → B2Σ+), and further attempts to achieve high scan rates for time-resolved measurements. The experimental set-up employs a broadband Laser Driven Light Source (LDLS, Energetiq-Hamamatsu), which is pitched through the tube by means of a set of mirrors at 20.38 m downstream of the diaphragm. The total radiance is captured at the opposite side, including contributions from the absorbed source intensity, as well as the gas emission. As the spectral power density of the source is generally not sufficient to overcome the intensity from the spontaneous emission of CN(B2Σ+ → X2Σ+), a similar set of optics was used to capture the emission radiance at an orthogonal direction.

For a condition at 0.09 Torr and 4.01 km/s at 15.7 cm after the shock, the measured radiance before emission subtraction indicates absorption was present at this condition. The logarithmic ratio of the emission-subtracted signal to the reference signal gives the spectral absorbance. This is fit using NEQAIR to provide rotational and vibrational temperatures, as well as the CN(X) density, giving Tr = 5727 K, Tv = 4772 K, and nCN(X) = 2.89 × 1014 1/cm3, respectively. The quality of the corrected absorbance measurement is degraded at higher velocities, as emission becomes comparable to the absorbed reference signal. Attempts were carried out coupling the spectrometer to a high-speed camera (Phantom v2512), to achieve a repetition rate of 100 kHz for time-resolved measurements. The spectral sensitivity of the camera, however, represented a major limiting factor in measuring the high-absorbance Δv = 0 sequence. Improvements in the light coupling efficiency, as well as the use of different sensors, are currently under
study.

Presentation not included in conference proceedings. This abstract has been approved for public release.

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